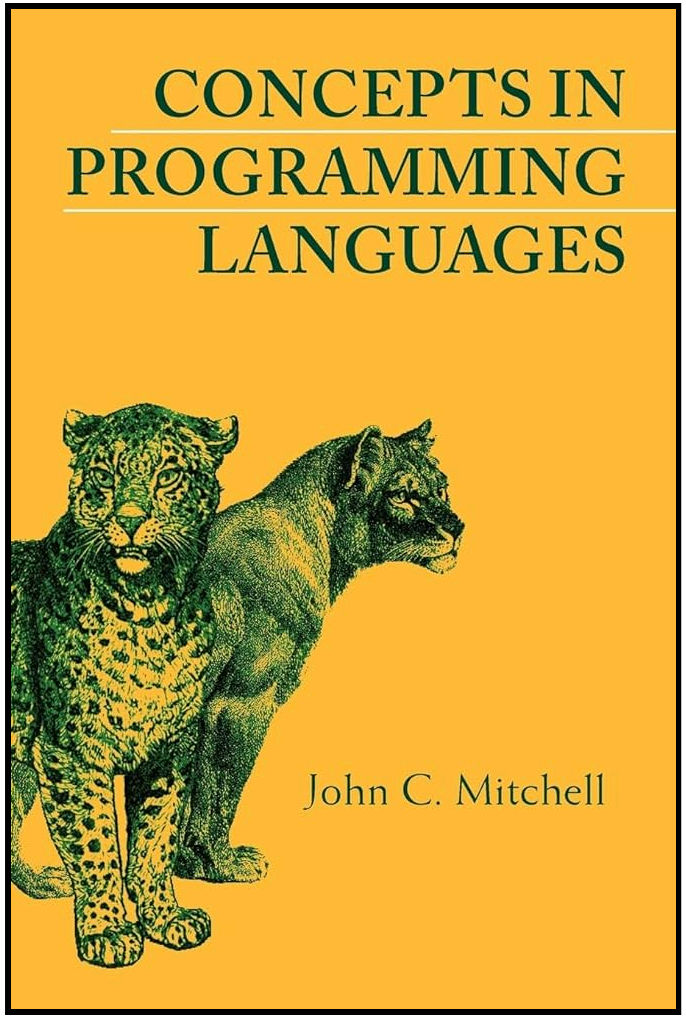
TinySelf: Tiny object-oriented language

History and foundations

Tomas Petricek, Charles University

tomas@tomasp.net
@tomasp.net
https://tomasp.net
https://d3s.mff.cuni.cz/teaching/nprg077



Object-orientation

Dynamic lookup - object chooses how to respond

Abstraction - object state can be hidden from user

Subtyping - any compatible object can be used

Inheritance - reuse to implement a new object

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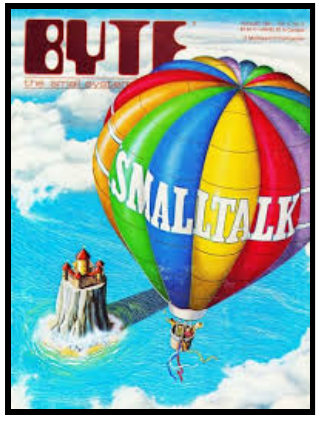
Brief history

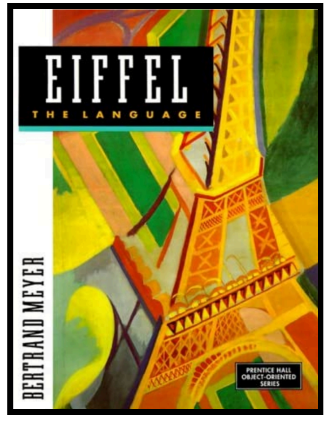
1960s-70s



Algol-based and scientific Simula

Tools for thought and messaging in Smalltalk

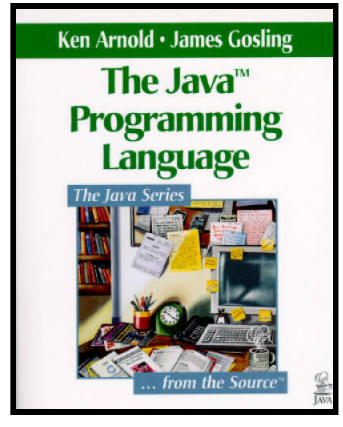
1980s



Rigorous Eiffel and "serious" C++

Prototypes and materialized objects in Self

1990s-2000s



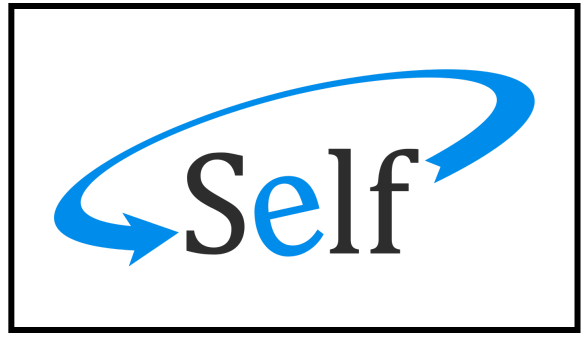
Class-based safe Java and C#

Prototypes in JavaScript and typed TypeScript

Why TinySelf?

"Pure" object-orientation

- Simple, uniform system
- Everything is an object (for real)
- Simpler than class-based Smalltalk



Shows the potential of objects

- Not Java-style organization of code
- Objects for code, state and execution!
- Objects with introspection and debugging!
- Objects and graphical interfaces!

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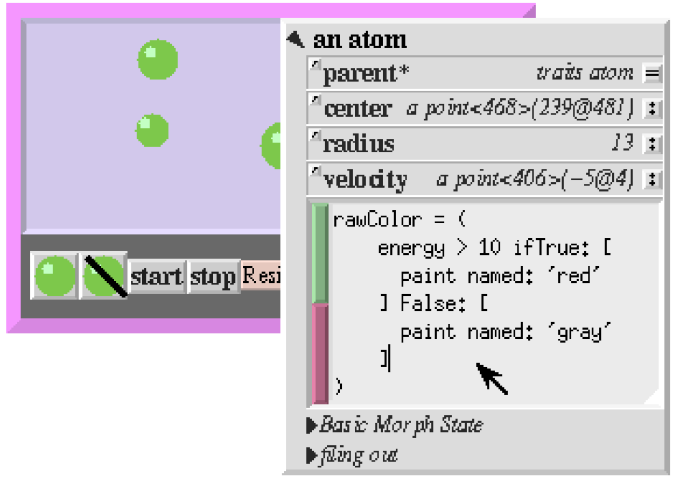

Figure 9. The user has selected one atom on which to experiment. The user changes the "rawColor" slot from a computed to a stored value by editing directly in the atom's outliner.

Self & Morphic user interface framework

Visual programming

Programming by graphically manipulating objects on screen

Direct programming

Objects on screen *are* objects in the system

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Demo

(Not so) Tiny Smalltalk

TinySelf

Scope of the implementation

- Prototype-based multiple inheritance
- Explaining basic runtime structures
- Methods with simple interpreted code
- Inaccurate interpreter in "Self style"

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TinySelf: Tiny object-oriented language

Using the Self programming system

Tomas Petricek, Charles University

tomas@tomasp.net
@tomasp.net
https://tomasp.net
https://d3s.mff.cuni.cz/teaching/nprg077

Everything is an object

Really everything

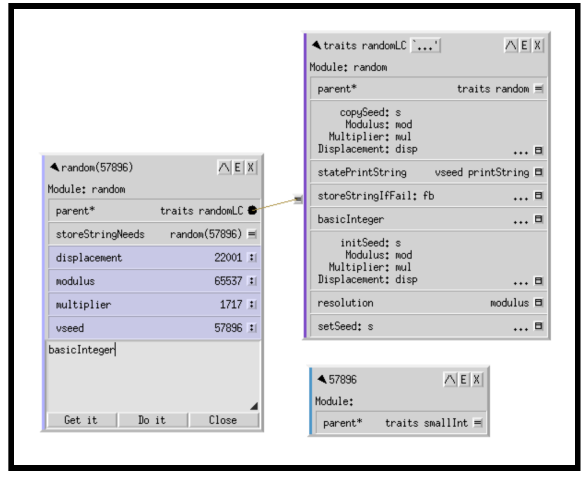
Objects, methods, lambdas, expressions, activation records

What is an object

Object has a list of slots and optionally contains code

Object = slots* + code?

- Data object has just slots
- Method object has code
- Closure has code and slots!
- Data object has methods as slots



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```
// Object consists of zero or more
// slots and optionally code
type Objekt =
  { mutable Code : Objekt option
    mutable Slots : Slot list }

// A slot has name and contents;
// Some slots are parents
and Slot =
  { Name : string
    Contents : Objekt
    IsParent : bool }
```

TinySelf objects

Object consists of zero or more slots and optional code!

In Self parent slot names end with *

TinySelf objects can also be special things

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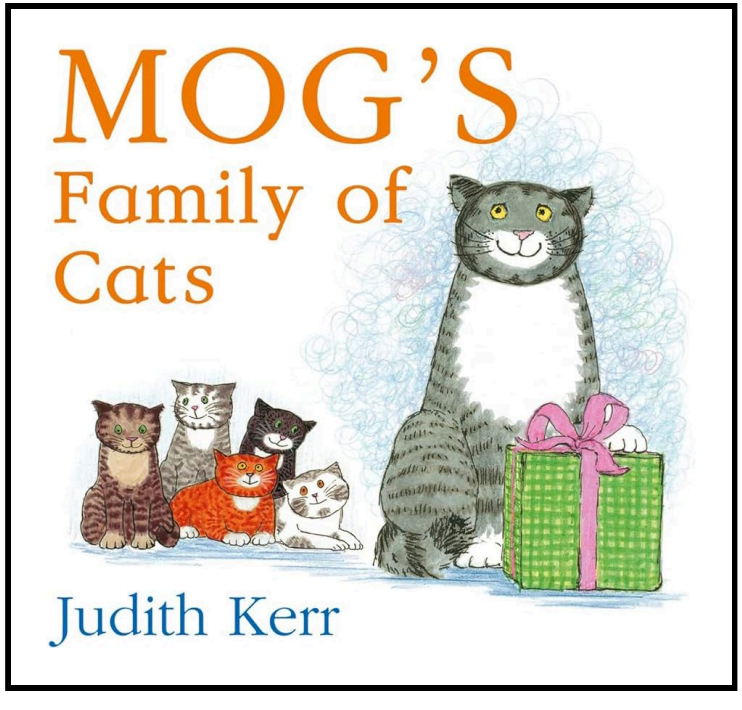

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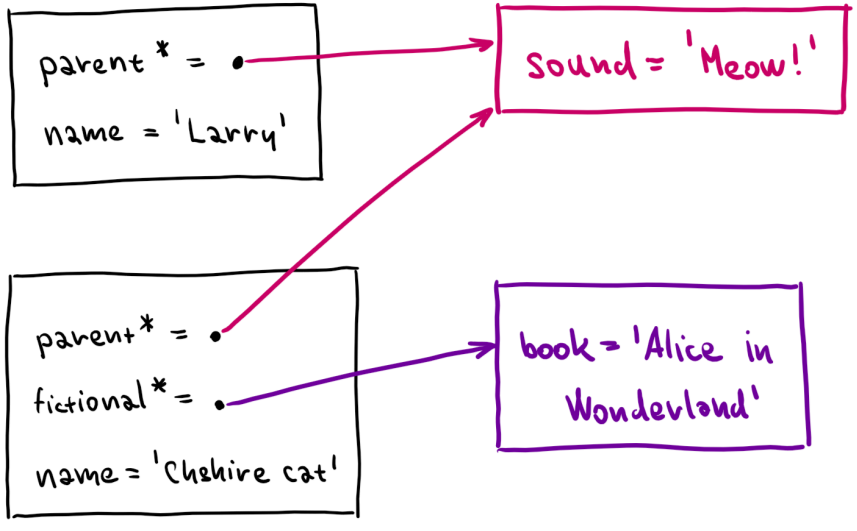

Prototypes and slots

Message send looks at target object first, then searches parents

```
cheshire name   // OK
cheshire book   // OK

larry name   // OK
larry book   // Fail
```

Message send fail if none or multiple slots found

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Demo

Representing cats in Self

```
"""Data object with name"""
(| book = 'Alice in Wonderland' |)

"""Method with  some code"""
( self name printLine )

"""Data object with parent
 slot and a 'speak' method"""
(| parent* = cat
   name = 'Cheshire Cat'
   speak = (
     self sound printLine
   )
|)

"""Data access or method call"""
cheshire name
cheshire speak
```

Message sending

Lookup slot with a matching name, then:

- If it contains data object, it is returned
- If it contains method, the method is called

Assignment slots and special calls differ...

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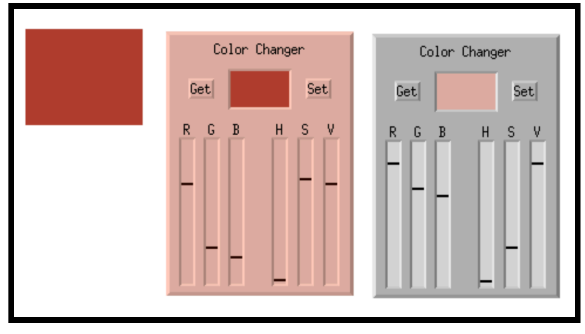
Demo

Hello world and traits

The power of simplicity...

Simplicity and uniformity

- All objects can be opened!
- Activation records for debugging
- Self-sustainable system



Morphic framework

- Things on screen are objects!
- Object with a morph prototype can draw itself
- User interface is just morphs - no special code!

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Demo

Morphic and graphical objects

TinySelf: Tiny object-oriented language

Working with mutable data in F#

Tomas Petricek, Charles University

tomas@tomasp.net
@tomasp.net
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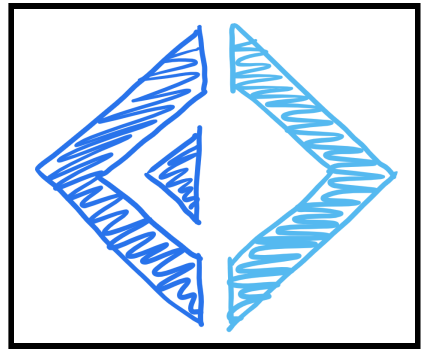
Mutable records in F#

Defining mutable objects

- Records with **`mutable`** fields
- We could use classes too



Equality and records

- Still use structural equality by default
- Not if records (can) contain functions!
- **`ReferenceEquality`** attribute to override

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Mutable records

```
type Person =
  { mutable Name : string
    mutable Book : string option }

let setName n p =
  p.Name <- n
let setBook b p =
  p.Book <- Some b

let x = { Name = "Bill"; k = None }
x |> setName "William"
x |> setBook "Alice in Wonderland"

match x with
| { Book = Some book } ->
  printfn "%s likes %s" x.Name book
| _ ->
  printfn "%s is sad :-(" x.Name
```

Helper functions

Make code a bit nicer

Can support **|>** pipe

Pattern matching

Same as immutable

Nice data extraction!

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Demo

Working with mutable records

TinySelf programming style

Different than before!

Everything is an `Objekt`
Type definition stays
We change what we put in!

Uniformity has drawbacks
Everything type checks!

Demo

TinySelf object visualizer

TinySelf programming style

Different than before!

Everything is an `Objekt`
Type definition stays
We change what we put in!

Uniformity has drawbacks
Everything type checks!

Helper methods

Simplify object construction

```
let makeString s =
  makeDataObject [
    makeParentSlot "parent*"
      stringPrototype
    makeSlot "value"
      (makeSpecial(String s))
    makeAssignmentSlot "value"
  ]
```

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TinySelf: Tiny object-oriented language

Code structure and step-by-step guide

Tomas Petricek, Charles University

tomas@tomasp.net
@tomasp.net
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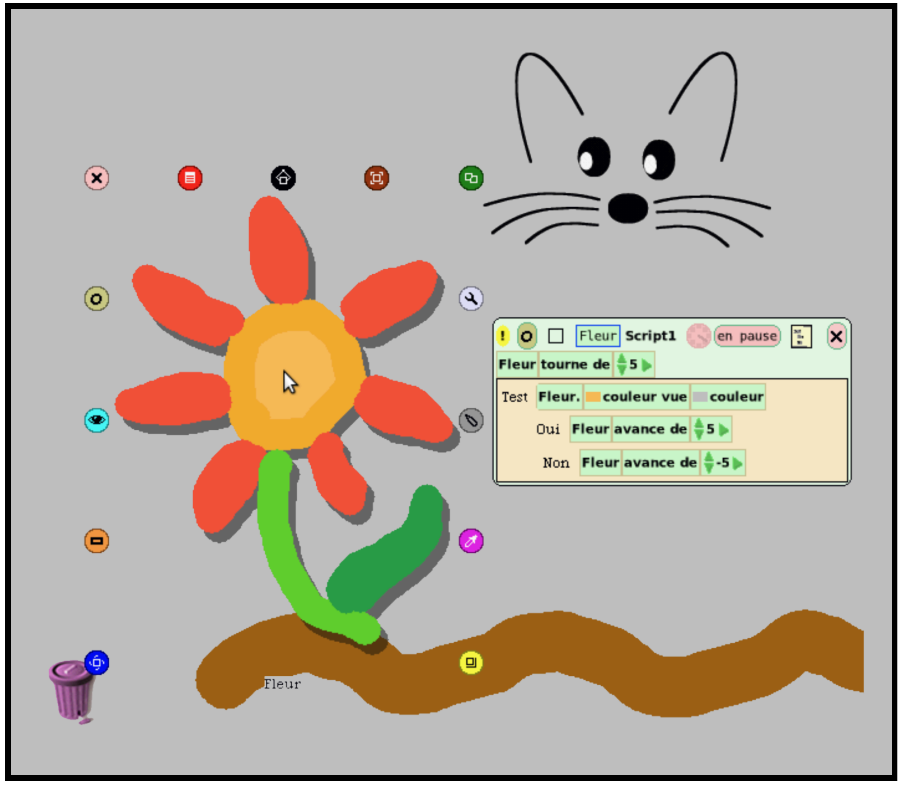

How Self-like systems put things on screen?

Escape hatch is a must
Smalltalk system calls
Self primitive calls
(primitives primitiveList)

TinySelf special objects
Primitive string values
Native F# methods

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```
// Special TinySelf objects!
type Special =
  | String of string
  | Native of (Objekt -> Objekt)

// Optionally special object
and Objekt =
  { mutable Code : Objekt option
    mutable Special : Special option
    mutable Slots : Slot list }

// Code to clone an object
let cloneCode =
  { Slots = []; Code = None
    Special = Some(Native(fun arcd ->
      lookupSlotValue "self*" arcd
      |> cloneObject )) }

// Method with special code object
let cloneMethod =
  { Slots = []; Special = None;
    Code = Some cloneCode }
```

Special objects

String values

No other way to represent strings!

Native methods

F# function taking "activation record" and returning the result

Used as method code

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Input:

`obj`, the object being searched for matching slots
`sel`, the message selector
`V`, the set of objects already visited along this path

Output:

`M`, the set of matching slots

Algorithm:

```
if obj ϵ V
then M ← ∅
else M ← {s ϵ obj | s.name = sel}
    if M = ∅ then M ← parent_lookup(obj, sel, V) end
end
return M
```

Where *parent_lookup(obj, sel, V)* is defined as follows:

```
P ← {s ϵ obj | s.isParent}
M ← ∪ lookup(s.contents, sel, V ∪ {obj})
   sϵP
return M
```

Slot lookup logic

Find a set of matching slots

1) Search target object

2) Search parents and union the results

3) Avoid infinite loops!

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Message sending logic

Self handbook

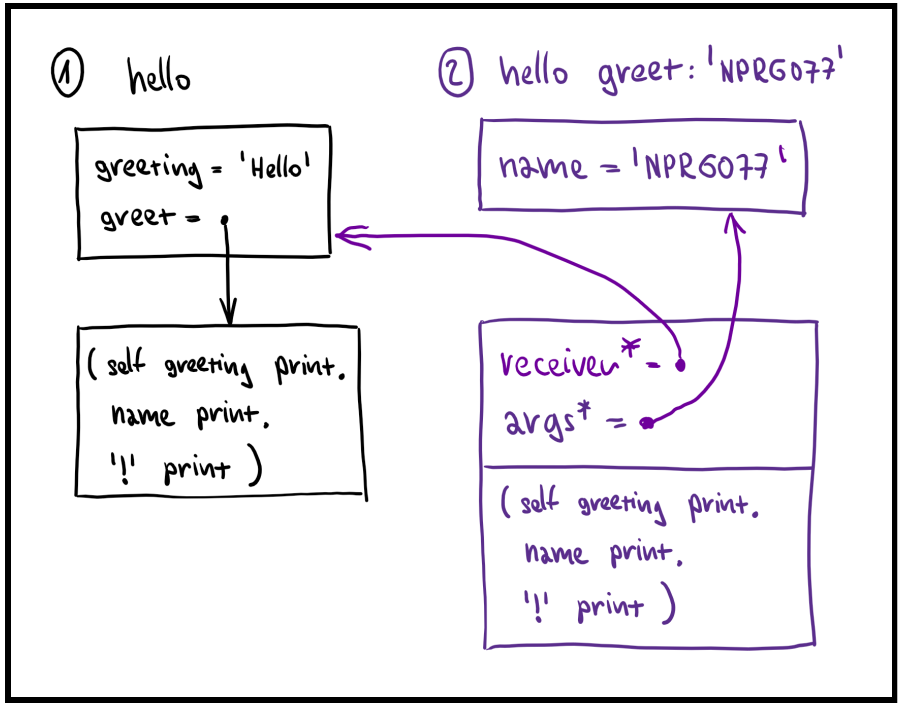
A normal send does a look-up to obtain the target slot;

If the slot contains a data object, then the data object is simply returned.

If the slot contains a method, an activation is created and run.

TinySelf translation

1. Find slot using lookup!
2. Check it is exactly one
3. If there is no code, return it
4. If there is code, run it...
    - Create activation record
    - Run (non-)native code



Activation record

Lookup in activation record to get all our code needs!

Clone of method

It could have data!

Self as parent

Access target's slots!

Arguments as parent

Access arguments!

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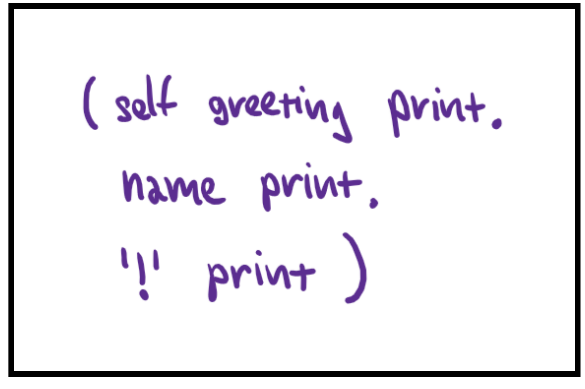
Sketch

How methods are invoked

Representing TinySelf code

AST is a tree of objects

- Objects store sub-expressions etc.
- Ordinary recursive F# interpreter



More object oriented?

- All nodes have **`eval`** method
- Becomes (a bit) too hard to implement!

Benefits and drawbacks

- Both options differ from actual Self/Smalltalk
- Simpler than actual compiled methods!

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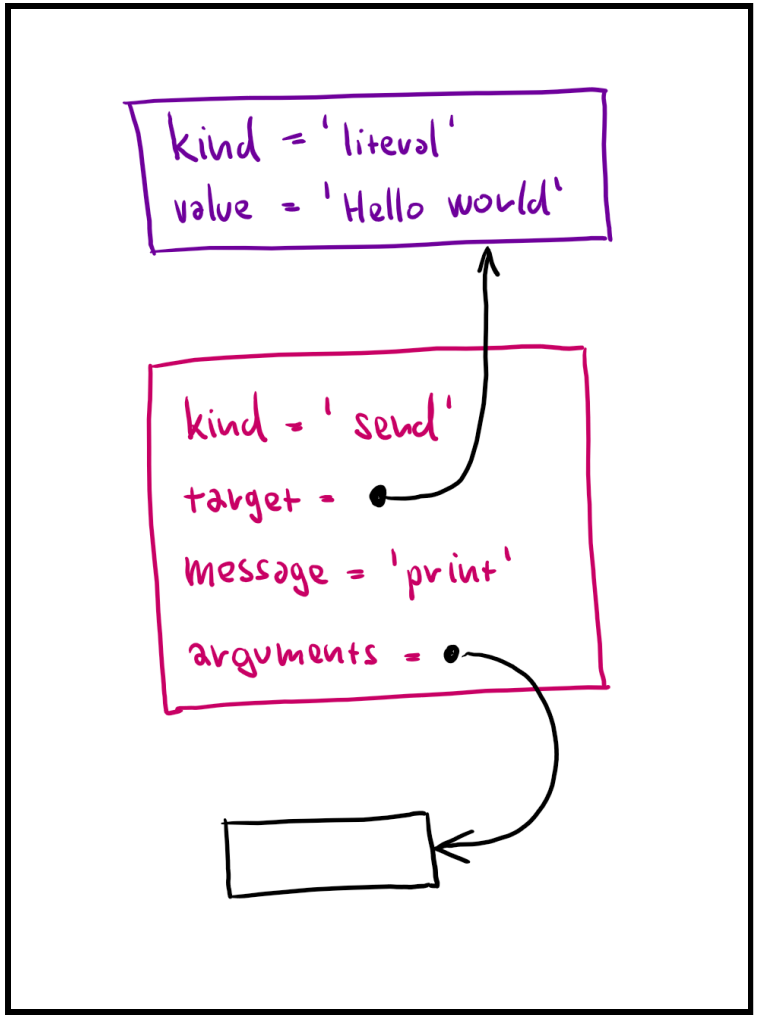

Simple expression

```
'Hello world' print
```

Send expression

Receiver, message, arguments to be used

String expression

String value to be returned

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Lab overview

TinySelf system step-by-step

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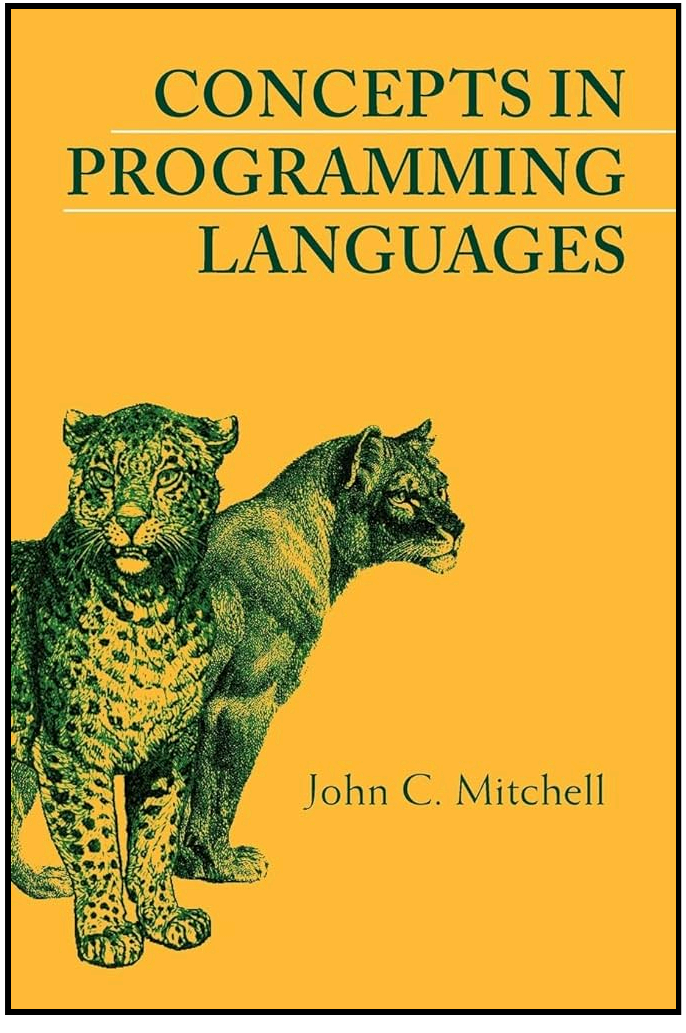
TinySelf - Basic tasks

1. Implementing slot lookup and strings
   Traversing the prototype hierarchy to find slots
2. Implementing (basic) message sending
   Returning data slots and calling (native) methods
3. Adding method arguments and assignments
   Creating assignment slots and revised activation records
4. Object-oriented Booleans and conditionals
   Higher-order methods with blocks
5. Representing & interpreting TinySelf expressions
   Creating expression objects and an interpreter

TinySelf - Bonus and super tasks

1. Arguments and sequencing of expressions
   Adding more types of expressions to TinySelf
2. Revisiting Booleans and conditionals
   Representing TinySelf code with conditions
3. Objects as lists and more expressions
   Adding more infrastructure before the next step...
4. Creating web-based visualizers
   A small step towards TinyMorphic framework



TinySelf and OO

Dynamic lookup

Find method using lookup

Abstraction

No private slots in TinySelf

Subtyping

Object with required slots

Inheritance

By setting a parent slot

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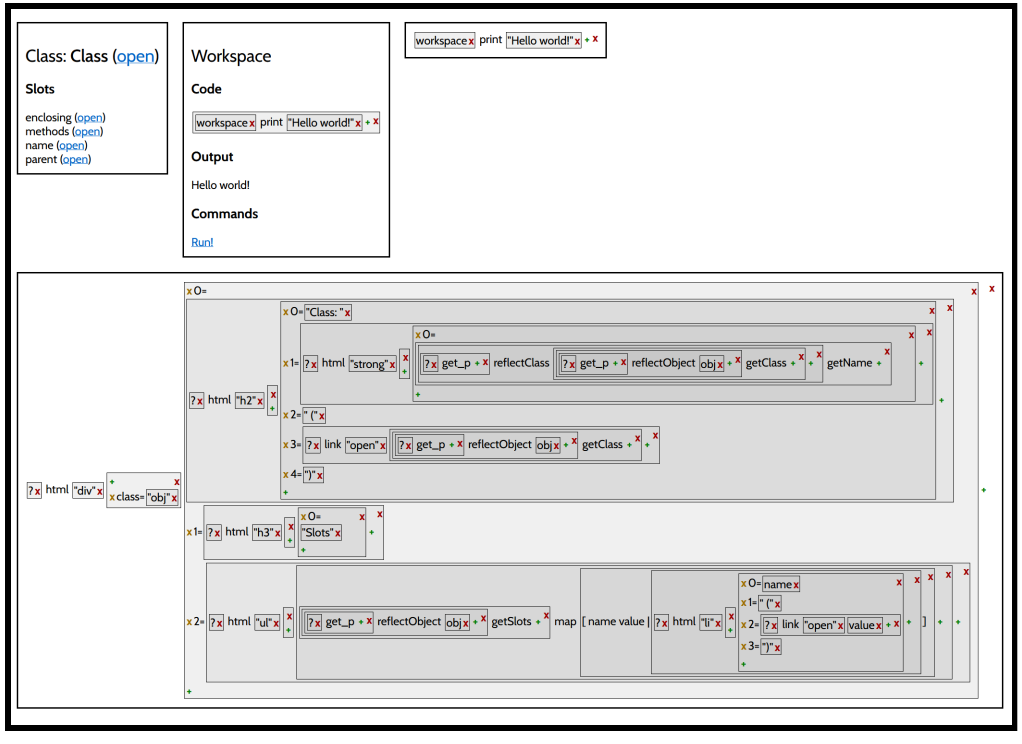

What is missing

Self-sustainable

Complete basic library

Reflection capabilities

Reflection via mirrors

Mirror objects

Inspect & modify

Done in Nanospeak

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Lessons learned

A tiny prototype-based OO language

 Basic logic of object-oriented languages

 Shows how to build self-sustainable system

 Different implementation - everything is object

 Hard to implement! Need debuggers, not types

https://bibliography.selflanguage.org/

https://bibliography.selflanguage.org/_static/self-power.pdf

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https://sin-ack.github.io/posts/a-tour-of-self/

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